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SOME NEW ASPECTS OF PLANT NUTRITION

By Dr. R. W. THATCHER

PRESIDENT OF THE MASSACHUSETTS STATE COLLEGE

FOR many years I have been keenly interested in the biochemistry of plant life. My interest in this field was first aroused when I first learned of the antithetical but complementary relationships of plant and animal life as shown by the so-called "cycles" of life, such as the "carbon cycle," the "nitrogen cycle," etc., in which plants take from and restore to the atmosphere or soil the elements which are given to and withdrawn from these same ultimate sources of supply by the processes of animal life. This led to a further interest in the biochemical processes and exchanges of energy in syntheses by plants and in metabolism by animals. Soon it became apparent to me that while these processes are generally antithetical in direction and final results, the route along which they travel and the conditions which determine their velocities are strikingly similar.

For example, the pigments which are associated with the rate, and in a sense the regulators of, energy changes in plant and animal growth, namely, haemoglobin and chlorophyl, respectively, were shown to be strikingly similar in chemical constitution, being made up of the same pyrrol units linked together in the same general relationships, the only essential difference being in the metallic element through which the linkage occurs, namely, iron in haemoglobin and magnesium in chlorophyl. Moreover, within the past two or three years, it has been shown, as will be discussed later in this paper, that the element copper has apparently the same relation to the production of chlorophyl in chlorotic plants that it has to the regeneration of haemoglobin in anemic animals.

Again, enzymes, or organic catalysts, once they were discovered and the nature and method of their action studied, showed remarkable similarities in the plant and the animal biochemical processes which they initiate or regulate. In fact, the reversibility of the reaction which is accelerated by a particular enzyme

is often illustrated in antithetical processes of plant and animal life.

As I became interested in these matters and began to study possibilities of research in the field of the chemistry of plant life, I found that the term "biochemistry," although etymologically embracing the chemistry of all life processes, was generally used only in connection with animal investigations, and its branch, known as "physiological chemistry," was used almost exclusively as referring to the chemistry of animal life processes, especially those of human physiology. In fact, nearly if not all of the departments and laboratories of biochemistry in this country were at that time (some twenty years ago) organized in the medical schools. A few laboratories in Europe, such as those of Willstätter, Euler, Czapek and Emil Fischer, were beginning to study the chemistry of the organic compounds found in plant tissues and the newly discovered group of enzymes, or "organic ferments," as they were called, were being found to exist largely in plant organisms, so that active interest in the biochemistry of plant life was beginning to appear.

Early in 1913, I went to the University of Minnesota to become head of the department of agricultural biochemistry, with the intention on my part and the understanding of the administration there that I would attempt to develop a corps of workers and a program of research in the field of the biochemistry of resistance to disease in plants. Work on this program went far enough to demonstrate conclusively that there is a series of biochemical phenomena and processes in plants, by means of which they are either sensitive or resistant to infection by parasites, which are quite comparable, if not actually parallel, to the biochemical processes by which the animal body reacts to infectious and parasitic diseases. My own connection with this problem ceased because of my transfer to administrative work, and much of the subsequent program of the department of agricultural biochemistry at the University of Minnesota has since been done in the field of animal and human biochemistry. But enough of the progress that has been made upon the original program has come to my knowledge to keep alive my keen interest in the general problem of the parallelism of the biochemistry of plant and of animal life.

Quite recently, I have become interested in the possible parallelism between certain aspects of the nutrition of plants and of animals which has thus far escaped notice and which I believe to be worthy of careful investigation. In fact, I am already laying out a tentative program for a series of studies in this field when I transfer to the research professorship in the Massachusetts Agricultural Experiment Station, which the board of trustees has made available to me after my retirement from my present position.

My fundamental thesis is that there already is enough experimental evidence to justify the formulation of a hypothesis that there exists in the field of plant nutrition a series of phenomena which are quite comparable in their operation and effects to those which are now recognized and accepted in the field of animal nutrition as being due to the existence of and necessity for certain accessory food substances commonly known as "vitamins."

Prior to about twenty years ago animal nutrition was studied and feeding standards or human dietaries were recommended wholly on the basis of a so-called "balanced ration" of the essential groups of nutrition known as the proteins, fats, carbohydrates and salts or mineral nutrients. These types of animal nutrients were all well-known chemical compounds, whose presence in foods or in animal tissues could be readily detected, both qualitatively and quantitatively, by chemical analysis. In 1906, however, Eijkman, a Dutch chemist working in Java, and Hopkins, in England, both postulated the existence of certain accessory food substances of an entirely different type, the absence of which from the diet produces certain specific nutrition-deficiency diseases. In 1911, Casimir Funk gave the name "vitamin" to the one of these accessory food materials which is preventative of beri-beri or polyneuritis, because of a conception, which was later proved to be erroneous, that its specific beneficial effects were a function of the chemical constitution indicated by this particular name. Funk also believed that other similar acessory food substances would be found to have similar chemical constitution and that the name "vitamins" might properly be used as a general group name. This is, of course, now known not to be true. However, this name has survived competition with other suggested names for popular use as a group designation.

Following the announcement of the vitamin hypothesis, a tremendous amount of study has been directed toward the solution of questions of how many such vitamins actually exist, of the chemical constitution of each vitamin itself, of the specificity of its requirement for a particular physiological function in the animal body, and of the natural sources for each particular vitamin. Naturally, a first step in all this work has been the devising and perfection of methods of technique for determining both qualitatively and quantitatively the presence or absence of any one of these substances in any product which is under investigation. Since their chemical constitution is as yet unknown, this technique must, at present, be based upon measurements of their biological effects

instead of upon specific chemical tests for their presence in the material which is studied.

My point is that the discovery of these essential elements of animal nutrition, which are necessary in much smaller quantities than is true of the other nutritional substances and whose chemical nature is not yet known, has developed, during the last twenty years, an entirely new type of investigation, which already has produced results of tremendous theoretical and practical importance to human welfare. Further, it is a field to which a large group of highly trained specialists are devoting a major part or all of their research activities. It is to the possibilities of a similar development in the field of plant nutrition that this paper is intended to direct attention.

Turning now to the possible parallelism in the field of plant nutrition to the developments in the field of animal nutrition that I have just mentioned, I may point out that prior to about twenty years ago problems of "soil fertility" (which was the term used to describe the supply of anergic plant food from the soil to crops) were considered solely from the standpoint of a few so-called "essential elements," whose presence in the soil or plant in question can readily be determined by standard methods of chemical analysis. Field and plot tests to ascertain whether profitable economic returns are possible from the use of "fertilizers" dealt almost exclusively with the three of these elements which are called the "critical elements of fertility," namely, phosphorus, potassium and nitrogen. Sulfur and calcium also began to be generally recognized as possible limiting factors in soil productivity and later magnesium was added to the list as necessary to be considered in some special cases. Iron, silicon and possibly sodium and aluminium were known to be taken from the soil by plants, but were generally so abundant in all agricultural soils that, while often mentioned as "essential elements," they were not much studied in connection with practical problems of plant nutrition.

In all such considerations the problem was that of the supply of these elements as plant food in proper amounts and proportions, entirely similar to the basis of total nutrients and balanced ration in animal feeding, and the general methods of chemical analysis of materials and of feeding trials were similar in purpose and character in the two fields of nutrition. Fertilizer formulas, comparable to feeding standards for farm animals and human dietaries, were based upon supplies from appropriate commercial materials of these critical elements in properly balanced proportions.

To be sure, the literature of the subject for the past fifty years has contained occasional references to the finding of other elements more or less widely present in small amounts in plant tissues, and an occasional speculative consideration of their possible physiological function or necessity to plant life. In fact, Palladin, in his "Plant Physiology," published in 1923, lists 31 chemical elements as having been reported to have been found by chemical analysis to be present in plant tissues. However, even at that late date, he includes only the commonly accepted ten in his list of the "essential elements of fertility."

But beginning about twenty years ago, experimental evidence was accumulated to show that certain elements which had been found in plant tissues in such small amounts as to be considered more or less accidental constituents, taken from the soil by purely mechanical processes and hence not essential plant nutrients, are actually just as necessary to plant growth as are the other mineral elements of fertility.

For example, Miss Brenchley[1] at Cambridge, in England, published in 1914 a monograph entitled "Inorganic Plant Poisons and Stimulants," reporting the results of her studies of the use in plant nutrient solutions of salts of copper, arsenic, manganese, zinc, and boron, which were assumed to be toxic to plants, in proportions less than injurious dosages, in which she found that in such proportions salts of manganese, zinc and boron gave positively stimulating effects upon plant growth, varying, however, with the different crops and producing varying anatomical changes in the growing plants. She found copper and arsenic salts not to be "stimulating," even in minute dosages.

In this country, McHargue and his associates at the Kentucky Experiment Station,[2] demostrated that copper, manganese and zinc, in "very small amounts," are essential to growth of many, if not all, farm crops. Lipman and his associates at the University of California[3] showed that while boron, in the form of salts of boric acid, is positively toxic to farm crops if present in the soil to the extent of three parts per million or more, lesser amounts than this are so necessary as to be an actual limiting factor in crop production if absent from the nutrient medium. Numerous other experimental results of similar purport are current in the literature of soil science in this country and abroad for the past ten years, some of which will be referred to a little later in this paper in connection with the nutrient functions of particular elements.

I think that it is not stretching the truth in favor

[1] Winifred E. Brenchley, "Inorganic Plant Poisons and Stimulants." Cambridge University Press, London, 1914.

[2] J. S. McHargue, "The Occurrences of Copper, Manganese, Zinc, Nickel and Cobalt in Soils, Plants and Animals, and their Possible Function as Vital Factors," *Jour. Agr. Research*, 30 (No. 2): 193–196. 1925.

[3] A. L. Sommer and C. B. Lipman, "Evidence on the Indispensable Nature of Zinc and Boron for Higher Green Plants," *Plant Physiology*, 1 (No. 3): 231–249. 1926.

of my hypothesis of parallelism of these facts and phenomena of plant nutrition to those of the vitamin relationships in animal nutrition to point out the following points of similarity.

First, the essential nature of these elements to proper plant nutrition was first discovered, in many cases, by plant pathologists in connection with experimental studies of the causes of and possible remedies for so-called "physiological" or "nutritional" diseases of farm crops, or as a result of observations of beneficial results upon crop yields of applications of these materials to crops as fungicidal sprays which could not be accurately attributed to control of parasitic diseases.

Second, only very minute amounts of these elements are necessary to accomplish their essential function in nutrition.

Third, these accessory elements of plant nutrition are generally so widely distributed in soils (the natural source for anergic plant food), in adequate amounts for general crop needs, that definitely recognized deficiency diseases due to an inadequate supply of them are relatively rare and limited to special soil or crop conditions; while, on the other hand, there is already some evidence that the addition of small amounts of these accessory elements to soils previously considered to be adequate sources of necessary plant nutrients gives beneficial results in increased vigor of growth and final yields of crops.

Fourth, in many cases, some of which will be detailed in later paragraphs of this paper, absence or inadequacy of these elements in the nutrient medium has been shown to result in definite and specific anatomical abnormalities or abnormal physiological functioning in the plant or crop in question, quite similar to, if not actually parallel with, the symptoms of vitamin-deficiency abnormalities in animals.

In fact, it seems to me to be no very visionary idea to suppose that we may soon recognize in the field of plant nutrition certain definite factors which may be designated by some such terms as "the anti-chlorosis factor," "the meristem-stimulating factor," "the inflorescence stimulator" and the like, comparable to the "anti-scorbutic," "growth-promoting," "antisterility" vitamins. As examples of what I mean, may I cite the following:

Copper has been found by Allison[4] to be a specific limiting factor in the growth of at least sixty different crop plants on the raw peat lands of the Florida Everglades and by Felix[5] for onions and lettuce on the reclaimed muck lands of central New York. In the latter case, lack of copper produces a specific anatomical abnormality, known as "rabbit-ear," in that lettuce which should develop solid "heads" produces instead long slender leaves which are the basis for the common name of the trouble. Onions, too, are reported to produce better-colored and thicker "scales" when fertilized with copper sulfate. In Florida, the general evidence of absence of copper in the soil is a marked chlorosis of the foliage of the plants, which may be remedied by addition of as little as 10 pounds per acre of copper sulfate to the soil or by spraying of dilute solutions of copper salts upon this foliage. The descriptions of the results of experimental studies of the chlorophyl regeneration in these copper-starved plants are strikingly similar to those of the specificity of copper as a necessary adjunct to iron in the regeneration of haemoglobin in artificially produced anemia in animals by Hart and Peterson[6] and their associates at the University of Wisconsin.

Manganese has been found by several different investigators to be a specific remedy for chlorosis of plants due to excessive lime in the soil. But its action is not general, in that on the same soil, or in the same culture medium, its beneficial effects will be shown by some crops and not by others. Willis, of North Carolina,[7] reports that manganese sulfate overcomes this type of chlorosis on soybeans but not on corn. McHargue, in Kentucky,[8] finding similar results, suggests the association of manganese with chlorophyl-formation similar to that of copper already mentioned. Mann[9] has offered an explanation of the North Carolina results on the basis of a specific requirement of soybeans for this type of aid in chlorophyl formation.

Workers at the Rhode Island Agricultural Experiment Station[10] found beneficial results from the use of as little as 8 pounds per acre of manganese sulfate applied to the soil as a fertilizer, which could be duplicated by applying the chemical to the foliage in a spray. But recent experiments at the Connecticut

[4] R. V. Allison, O. C. Bryan and J. H. Hunter, "The Stimulation of Plant Response on the Raw Peat Soils of the Florida Everglades through the Use of Copper Sulfate and Other Chemicals," *Fla. Agri. Exp. Stat. Bul.*, 190: 33–80. 1927.

[5] E. L. Felix, "Correction of Unproductive Muck by the Addition of Copper," *Phytopathology*, 17 (No. 1): 49–50. 1927.

[6] J. Waddell, H. Steenbock and E. B. Hart, "The Specificity of Copper as a Supplement to Iron in the Cure of Nutritional Anemia," *Jour. Biol. Chem.*, 84 (No. 1): 115–130. 1929.

[7] L. G. Willis, "The Response of Oats and Soybeans to Manganese on Some Coastal Plains Soils," *No. Car. Agric. Exp. Sta. Bul.*, 257, pp. 13. 1928.

[8] J. S. McHargue, "The Occurrence and Distribution of Manganese," *Ky. Agri. Exp. Sta. Rept.*, Pt. 1, 16–18. 1926.

[9] H. B. Mann, "Availability of Manganese and of Iron as Affected by Applications of Calcium and Magnesium Carbonates to the Soil," *Soil Sci.*, 30 (No. 2): 117–141. 1930.

[10] B. E. Gilbert and F. T. McLean, "The Lack of Available Manganese in a Lime-Induced Chlorosis," *Soil Sci.*, 26 (No. 1): 27–31. 1928.

Tobacco Station[11] resulted in abnormal physiological symptoms in tobacco if the amounts of manganese in the soil exceeded a certain optimum.

Boron, in the form of salts of boric acids, especially borax, has been known for some time to be very toxic to farm crops if in concentrations of more than three parts per million in the nutrient medium. But in less concentrations (the optimum being about 1:1,500,000) it has been found by Lipman and his associates[3] at the University of California, by Brenchley[12] in England and by Warrington[13] in Sweden to be absolutely indispensable for satisfactory growth of many crop plants. Both Miss Brenchley and Miss Warrington report that insufficient supplies of boron in the nutrient medium result in definite anatomical abnormalities in the plants, particularly retardation of the development of meristem tissue, with certain specific discolorations in the stems of the plants which are recognizable as definite diagnostic symptoms for the boron-deficiency.

Zinc has been shown, by Sommer,[14] by Brenchley[1] and by McHargue and Shedd[15] to be a specific necessary nutrient for certain types of crops, but apparently not so, at least in the same degree, for others. The macroscopic evidence of zinc-deficiency is cited as an alteration of the normal proportion of straw and grain, but this is of course only a final result of some disturbance in the plant's metabolism or physiological processes the nature of which has not yet been studied.

These examples are probably adequate to indicate the basis for my assumption of a series of phenomena and principles of plant nutrition parallel to or at least comparable with the vitamin function in animal nutrition.

Fortunately for the proposed experimental study of this hypothesis, the elements to which these specific nutritional functions are apparently attached are presumably well-known chemical entities, for which qualitative and quantitative methods of testing are already available, thus making unnecessary one type of investigation which is essential in vitamin studies. But there does remain to be done a large amount of experimental study of the conditions and limitations of the requirements for these accessory factors of plant nutrition, and of the forms of compounds and conditions of protoplasm under which they exert their specific effects, together with a wide range of studies of the actual ill effects, physiologically and anatomically, of deficiencies in the diet of different types of farm crops of these plant "vitamins." For this latter type of studies, a new technique will probably have to be developed, as was the case with the animal vitamins. I believe, however, that this is a very promising field of research, and, as I said, I hope to have an opportunity soon to enter upon a definite program of investigations in it. It is to possible cooperation in this undertaking that I invite the attention of interested agronomists, chemists and plant physiologists.

THE RISE OF GENETICS. II

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Influence of the Genes on the Cytoplasm

If another branch of zoology that was actively cultivated at the end of the last century had realized its ambitions, it might have been possible to-day to bridge the gap between gene and character, but despite its high-sounding name of *Entwicklungsmechanik* nothing that was really quantitative or mechanistic was forthcoming. Instead, philosophical platitudes were invoked rather than experimentally determined factors. Then, too, experimental embryology ran for a while after false gods that landed it finally in a maze of metaphysical subtleties. It is unfortunate, therefore, that from this source we can not add, to the three contributory lines of research which led to the rise of genetics, a fourth and greatly needed contribution to bridge an unfortunate gap. I say this with much regret, for, during that time and even now, I have not lost interest in this fascinating field of embryological experimentation. It is true that a great deal of factual evidence came to light, and it is true that many misleading ideas were set aside, but the upshot was negative so far as the formulation of any of the factors of development, whether mecha-

[11] H. G. M. Jacobsen and T. R. Swanback, "Manganese Toxicity in Tobacco," SCIENCE, 76 (No. 1812): 283–284. 1929.

[12] Winifred E. Brenchley, "Investigations on the Effect of Boron on Plant Life," *Agr. Prog.* (*Agr. Ed. Assn., London*), 3: 104–105. 1926.

[13] Katherine Warrington, "The Changes Induced in the Anatomical Structure of *Vicia faba* by the Absence of Boron from the Nutrient Solution," *Ann. Bot.* (*London*), 40 (No. 157): 27–42. 1926.

[14] A. L. Sommer, "Further Evidence of the Essential Nature of Zinc for the Growth of the Higher Green Plants," *Plant Physiology*, 3 (No. 2): 217–221. 1928.

[15] J. S. McHargue and O. M. Shedd, "The Effect of Manganese, Copper, Zinc, Boron, and Arsenic on the Growth of Oats," *Jour. Am. Soc. Agron.*, 22 (No. 8): 739–746. 1930.

nistic or otherwise, are concerned. This may be because the work was pioneer and largely qualitative. Perhaps my disappointment at the outcome of the work has led me to an overstatement of its failures. Something did emerge that the future may show to be of fundamental importance for genetics. I mean the experimental demonstration that the immediate factors in the differentiation of the embryo are, at the time of their activity, already in the cytoplasm of the cell. Second only in interest was the discovery that, within certain limitations, the already determined specificity may be reversed, or rather, shall I say, the initial steps already taken are reversible by factors extraneous to the individual cells.

These statements call for further elaboration, because they are unconsciously in the background of much of our thinking about genetic problems, and should if possible be more sharply formulated.

That the form of cleavage of the egg is determined by the kind of chromosomes it contained before the egg reached maturity has been sufficiently proven; and since the foundations of all later differentiation are laid down at this time, the demonstration is of first-rate importance for genetics, because it shows that we are not obliged to suppose the genes or chromosomes are functioning at the moment of the visible appearance of characters.

This is demonstrated by introducing into the egg foreign sperm of a species having another type of development. Although the chromosomes from the sperm are present from the first cleavage onward, they produce at first no effect on the cleavage; only after a time do they succeed in bringing about changes in the embryo. This evidence is, as I have said, important for our genetic analysis, for it serves as a warning that the time relations between gene and cytoplasm may have a relation different from that of an immediate dynamic change in the cytoplasm. The preparation for the effect may have taken place long before the actual event.

The second inference is no less significant. I need not labor the point at this late date that the characters of the individual are the product both of its genetic make-up and its environment. The earlier, premature idea, that for each character there is a specific gene—the so-called unit-character—was never a cardinal doctrine of genetics, although some of the earlier popularizers of the new theory were certainly guilty of giving this impression. The opposite extreme statement, namely, that every character is the product of all the genes, may also have its limitations, but is undoubtedly more nearly in accord with our conception of the relation of genes and characters. A more accurate statement would be that the gene acts as a differential, turning the balance in a given direction, affecting certain characters more conspicuously than others. But let us not forget that the environment may also act as a differential, intensifying or diminishing, as the case may be, the action of the genes.

The best illustration of this double relation is seen in the determination of sex. When an unpaired chromosome is present, in one or in the other sex, its genes determine, as a rule, whether a male or a female develops from each egg. Under environmental conditions which, as we say, are normal, the differential acts almost perfectly; but under other unusual conditions and in a few special cases its power may be partially overcome and even a reversal may take place. These unusual environmental conditions may be external agents, such as temperature or light. They may also be internal factors, such as hormones. Even "age" itself may bring about a reversal of sex in certain types. These statements are commonplaces to-day. The only differences of opinion concern the emphasis that one theorist places on the environment, and another on the genic composition.

In passing, a word may be said about the genes as sex factors or differentials. All through the 32 years of the present century there have been attempts to isolate (in a genetic sense) the sex-determining factors. At first, when the chromosome mechanism was discovered, the idea prevailed that one X, let us say, made a male, and two X's a female. The sex-chromosome itself was then taken as the differential. Very soon after this the idea that the sex chromosome was the carrier of a gene for sex suggested itself, and a search was started to locate such a gene or genes in this chromosome. More recent work on translocations has shown the probable futility of such an interpretation. The tendency at present is rather to look upon all the genes, or at least many of them, as sex-determining in exactly the same sense, as all or many of the genes have an effect on the development of each character. It may well be, however, that certain genes in the sex-chromosome (as in other chromosomes) are more influential than others in turning the balance one way or the other, but even so, it does not at the present moment—in the light of recent evidence—seem probable that a single gene for sex-determination is to be found in the X-chromosome any more than, in the contrary sense, there is a single gene for sex in any special autosome. Here again, some one or a few genes may be more influential than others, but this is also true to varying degrees of the gene for any other character. The theory of balance between the intracellular products of the genes is the most direct contribution to physiology that modern genetics has made. It is an idea familiar

to classical physiology as applied to organ systems, but a distinctly new contribution to cellular physiology. It may be a long time before these intracellular genic substances are isolated and purified (since there may be many steps between the actual primary substances and the end-product of such substances in the cell-plasm); nevertheless as a point of view the presence of genic materials rather than a dynamic action of the nucleus is supported by some analytical evidence. Already there is afoot in several quarters, and by methods partly genetic, partly physiological, partly embryological, partly physical and chemical, a decided effort to approach this problem.

If we could obtain these substances in pure condition we might then be in a position to speak more confidently of a quantitative study of gene-activities in the sense that chemistry is quantitative. Meanwhile there are other more practical methods by which we may construct provisional hypotheses as to the nature of the intracellular substances that are the products of the genes, namely, through a study of triploids, trisomic types, fragments of chromosomes and by analysis of crosses between different species. These openings do not, of course, exclude the possibility of the discovery of entirely new methods of approach.

Let us not forget that the idea of balance, as seen in the character, is really an old and familiar one to geneticists. For example, the intermediate character of the F_1 hybrid was generally interpreted as due to a conflict between the old and the new gene. Again, the familiar statement that characters are often affected by modifying gene-action that enhances or diminishes the effect of the primary gene, is another example of the intracellular balance of the activity of the genes.

What has been said so far relates to the action of the gene on the cytoplasm of its own cell—its intracellular action. Those of us working with insects or plants are apt to think of genetic problems in this way, and are inclined to consider mainly the effects that do not reach beyond the cells in which they are produced. But in other groups, especially birds and mammals, the effects of the genes are not always so limited. We are on the threshold of work concerned with the isolation of the so-called sex-hormones, the end-products of the thyroid gland, the pituitary, the thymus, and the substances isolated from the suprarenal bodies. All these substances produce their effects outside of the cells that manufacture them. In themselves they are far removed from the primary action of the genes.

In this connection certain work carried out by experimental embryologists should not be overlooked, beginning with the early experiments of Lewis in 1904 and culminating in the more recent work of Spemann. Here it appears as the result of grafting experiments that certain organs of the body develop in response to the vicinity of other organs, as when, for example, the lens of the eye of the frog is shown to be a response to the presence beneath the skin of the optic lobe. Similar and more far-reaching effects have been recently found for other organs of the embryo. The simplest interpretation, perhaps, is the setting free of a hormone by an embryonic organ or group of cells that calls forth a response in neighboring regions.

This and other evidence goes to show that gene-activity may produce results outside of the cells in which the first steps are initiated. The problem at present is one of immediate importance in the study of gynandromorphs, mosaics and intersexes.

Evolution

Sooner or later every geneticist is asked what bearing this work has on the theory of evolution. In the early years of the century when genetics was new, some of us tried to sidestep the question, partly on the grounds that genetics was not ready to discuss the bearing of the new work on evolution, but mainly because it seemed unfortunate to compromise the precise results of the new procedure with the evolution doctrine which, because it dealt with a historical problem, was largely speculative. After 32 years of activity, caution may still be the wiser course to pursue; yet, on the other hand, we are now prepared, I think, to make a more definite commitment. It is, of course, obvious that only those characteristics that are inherited can take part in the process of evolution. The only characters that we know to be inherited are those that arise first as mutants, *i.e.*, discontinuously, or, as we say, by a change in a gene. Here genetics has made a very important contribution to evolution, especially when it is recalled that it has brought to the subject an exact scientific method of procedure. If we compare our present status in this respect with the discussions of the old school of evolutionists concerning variability, there can be no question but that genetics has contributed valuable information.

In the second place, the objection has been not infrequently made that geneticists are dealing only with aberrant or abnormal characters—hence their results, however accurate, can have nothing to do with the kind of progressive changes that have made evolution of new types possible. Such objections have come largely from those who ignore what geneticists have done and are doing. The same objections have also come from those whose minds are closed to new evidence, or who can not distinguish between the value of tested and verifiable theories and vague views

or juvenile impressions with a teleological background or bias.

Without elaborating, I wish to point out briefly that there is to-day abundant evidence showing that the differences, distinguishing the characteristics of one wild-type or variety from others, follow the same laws of heredity as do the so-called aberrant types studied by geneticists.

Even this evidence may not satisfy the members of the old school because, they may still say, all these characters that follow Mendel's laws, even those found in wild species, are still not the kind that have contributed to evolution. They may claim that these characters are in a class by themselves, and not amenable to Mendelian laws. If they take this attitude, we can only reply that here we part company, since *ex cathedra* statements are not arguments, and an appeal to mysticism is outside of science.

There remains still the question of the causal origin of mutations. Here also some progress has been made, but the subject is admittedly by no means on the same footing as is our knowledge of the laws of inheritance. It behooves us, then, to be careful, for our progress in this respect has been slow and to some extent erratic. I mean by this that we have not yet found a method of producing specific results—*i.e.*, a method by which particular genes can be changed in a particular way.

Even here, however, something has been done. In the work with x-rays and heat the same mutants appear that are already known, and that have come up without treatment. In addition, new mutants appear, as they do also without treatment. If it can be shown on a large scale that the same ratio for known mutations holds for x-ray and for spontaneous mutations, we may have found an opening for the further study of the causes of certain types of mutation.

I have been challenged recently to state on this occasion what seemed to be the most important problems for genetics in the immediate future. I have decided to try, although I realize only too well that my own selection may only serve to show to future generations how blind we are (or I have been, at least) to the significant events of our own time.

First, then, the physical and physiological processes involved in the growth of genes and their duplication (or as we say their "division") are obviously phenomena on which the whole process of reproduction rests. The ability of the new genes to retain the property of duplication is the background of all genetic theory. Whether the solution will come from a frontal attack by cytologists, geneticists and chemists, or by flank movements, is difficult to predict, although I think the latter more promising.

Second: An interpretation in physical terms of the changes that take place during and after the conjugation of the chromosomes. This includes several separate but interdependent phenomena—the elongation of the threads, their union in pairs, crossing over, and the separation of the four strands. Here is a problem on the biological level, as we say, whose solution may be anticipated only by a combined attack of geneticists and cytologists.

Third: The relation of genes to characters. This is the explicit realization of the implicit power of the genes, and includes the physiological action of the gene on the rest of the cell. This is the gap in our knowledge to which I have referred already at some length.

Fourth: The nature of the mutation process—perhaps I may say the chemico-physical changes involved when a gene changes to a new one. Emergent evolution, if you like, but as a scientific problem, not one of metaphysics.

Fifth: The application of genetics to horticulture and to animal husbandry, especially in two essential respects; more intensive work on the physiological, rather than the morphological, aspects of inheritance; and the incorporation of genes from wild varieties and species into strains of domesticated types.

Should you ask me how these discoveries are to be made, I would become vague and resort to generalities. I would then say: By industry, trusting to luck for new openings. By the intelligent use of working hypotheses (by intelligence I mean a readiness to reject any such hypotheses unless critical evidence can be found for their support). By a search for favorable material, which is often more important than plodding along the well-trodden path, hoping that something a little different may be found. And lastly, by not holding genetics congresses too often.

OBITUARY

RALPH HOFFMANN

RALPH HOFFMANN, director of the Santa Barbara Museum of Natural History, met sudden death in a fall from a cliff on San Miguel Island, California, on July 21.

He was born in Stockbridge, Massachusetts, in 1870, was educated at Williston Academy, and graduated from Harvard University in 1890. After graduating he taught at the Browne and Nichols School in Cambridge. In 1910 he became head master of the Coun-

try Day School in Kansas City, Missouri, and in 1917 of the Country Day School in St. Louis. From 1920 to 1927 he taught in the Santa Barbara School for Boys, but in 1923 accepted the title of honorary director of the Santa Barbara Museum of Natural History and devoted his spare time to its development. In 1927 he was elected director, a position he held at the time of his death.

Although ornithology and botany were avocations during his years of teaching, he became well known throughout the country in both fields. In addition to contributions to the Nuttall Ornithological Club, *The Auk, Rhodora, Bird Lore* and *The Condor*, he published "A Guide to the Birds of New England and Eastern New York" in 1904 and "Birds of the Pacific Coast" in 1927.

Whenever he exhausted the birds of a region he turned to its plants. After his New England "Guide," he published the "Flora of Berkshire County." After his "Birds of the Pacific Coast," he began work on the flora of Santa Barbara County and especially that of the Channel Islands. Though the fall that resulted in his death came while he was collecting the island flora, his notes were in such shape that the list is appearing in the *Bulletin* of the Southern California Academy of Sciences.

Ralph Hoffmann possessed not only the thoroughness of the scientist, but also an enthusiasm so contagious that those who knew him, especially children, left his presence either with a newly awakened love for birds and plants or with an old interest doubled.

E. H.

RECENT DEATHS

DR. ULYSSES SHERMAN GRANT, professor of geology at Northwestern University since 1899, died on September 21, at the age of sixty-five years.

DR. THOMAS G. LEE, professor emeritus of comparative anatomy at the University of Minnesota, died on September 8, at the age of seventy-two years.

OUTRAM BANGS, curator of birds in the Museum of Comparative Zoology at Harvard University, died on September 22, in his seventieth year.

DR. JOHN WYNN GILLESPIE, professor of botany at the Arizona State Teachers College and formerly National Research fellow, died of pneumonia at Albany, Georgia, on September 13. He was on his way home from a summer's vacation spent in study at the Kew Herbarium.

DR. FRANK BILLINGS, dean of the faculty of Rush Medical College since 1899 and emeritus professor of medicine in the University of Chicago, died on September 20. He was seventy-eight years old.

DR. ASTLEY PASTON COOPER ASHHURST, professor of clinical surgery at the Graduate School of Medicine of the University of Pennsylvania, died on September 19. He was fifty-six years old.

THE REV. GEORGE W. LAY, of Chapel Hill, North Carolina, a member of the American Association for the Advancement of Science, who contributed articles to SCIENCE on scientific terminology, has died, at the age of seventy-two years.

THE deaths are announced of two distinguished British surgeons: Sir Henry Simpson, the obstetrician, on September 13, in his sixtieth year, and Sir Chester James Symonds, known for his work in abdominal surgery, on September 14, at the age of eighty years.

DR. FREDERICK HENRY HATCH, a past president of the British Institution of Mining and Metallurgy and a member of the governing body of the Imperial Institute, died on September 22, at the age of sixty-eight years.

SCIENTIFIC EVENTS

THE DAVID DUNLAP OBSERVATORY

THIS observatory, which, when completed, will be presented to the University of Toronto, to be conducted by its department of astronomy, is being erected by Mrs. Jessie D. Dunlap as a memorial to her husband, David Alexander Dunlap, who died in the autumn of 1924. It is located near the village of Richmond Hill, fifteen miles north of Toronto, one half mile east of Yonge Street, Ontario's great highway to the north.

There are two chief buildings. One, sixty-one feet in diameter, of metal, will house a reflecting telescope of aperture seventy-four inches. This instrument is being built by Sir Howard Grubb, Parsons and Co., of Newcastle-on-Tyne, England, and its construction is well advanced. The building is also being supplied by the same firm. It is intended to put in the cement foundations for the building and also the pier for the great telescope this autumn in order to let them weather the storms of winter. The building will be erected next spring and the telescope a little later. This telescope will be used chiefly for spectrographic work, though some direct photographs may be taken.

The administration building will contain offices, library, lecture room, laboratories, computing rooms and workshop. Plans for it were prepared by Mathers and Haldenby, of Toronto, and the corner stone was laid on September 10. It will be 91 feet long

by 49 feet wide, with semi-octagonal projections on each end. The material used is Credit Valley limestone, with Queenston stone trimmings, both obtained in Ontario. It will have two stories and a basement. On the roof will be three domes, those at the ends being 21 feet, that at the center being 25 feet in diameter. In one of the smaller domes there will be a 19-inch reflector (with pyrex mirror), which was constructed in the university workshops; in the other there will be a battery of cameras on a single mounting. The chief parts for these cameras are already on hand and the mounting will be made in the observatory workshop. In the central dome there will be a ten-inch refractor, which will be used for the observation of planets, comets, occultations and double stars, and it will also be available for public purposes. The domes are almost ready and the Administration Building will be completed next spring.

The observatory site is in the midst of a 179-acre plot of farmland, which will be made into a park to be known as the David Dunlap Park. It will be developed by the faculty of forestry of the university, and in the coming years will produce results of scientific value as well as being a pleasant resort for the people.

C. A. CHANT

NEW BUILDING FOR ENTOMOLOGY AT THE UNIVERSITY OF CALIFORNIA

THE new building for the Divisions of Entomology and Beneficial Insect Investigations of the Southern Branch of the College of Agriculture of the University of California is now open. The building is two stories in height, with basement and attic greenhouse.

In the basement is a spray application laboratory, with a garage entrance where spray outfits or trucks may enter, fumigation tent room, carpenter and mechanics shop, storage rooms, machinery and refrigeration rooms, and a large room containing the controlled environment equipment. This equipment consists of six independent cabinets where the temperature may be maintained within 1 degree and including a range of 30 degrees to 120 degrees Fahrenheit, with the full range of humidity at any given temperature. One of these cabinets is equipped with thermo-time-control where any fluctuating temperature is automatically controlled within a 24-hour period. The light may vary from complete darkness to 1,000 watts. The air surrounding these chambers is taken in from the outside and oil filtered, and when necessary, conditioned within a limited range so far as temperature and moisture are concerned.

On the main floor is the spray laboratory, insecticide laboratory and insect physiology laboratory, aside from the usual laboratories and offices, dark room and photographic room. On this floor is also the fumigation room, equipped with a duplex 100 cubic foot vacuum fumigator, and two other fumigating rooms. In one of these rooms, as well as in the vacuum fumigators, the temperature may be controlled between 30 degrees and 120 degrees Fahrenheit, as well as the humidity. This installation is equipped with special apparatus for the use of cyanide, carbon bisulphide, carbon dioxide, ethylene oxide, formaldehyde and other fumigants.

The second floor is occupied by the Division of Beneficial Insect Investigations and consists of a series of laboratories and offices, taxonomic laboratory and graduate student and seminar room.

The attic greenhouse for growing plants and the propagation of insects is connected with an electric elevator, enabling plants to be brought from the greenhouse to the fumigating chambers or to the controlled environment room in the basement.

THE JUNIOR SCIENCE CLUBS SECTION OF THE AMERICAN INSTITUTE

THE formation of a new organization, known as the Junior Science Clubs Section of the American Institute, was announced following a meeting of a committee of teachers of science in the schools of New York City held on September 22 at the headquarters of the American Institute.

According to a statement made by Dr. Morris Meister, head of the science department of the New York Teacher Training College, who is chairman of the Plan Committee, the plan has been approved by the Board of Education, the Standing Committee of Science Teachers of New York City and other educational and scientific bodies. Its membership will consist of the junior science clubs. Under the guidance of the American Institute, it will offer to the members of these clubs larger opportunities in the field of science than they have heretofore been able to enjoy.

The plans call for a series of afternoon demonstration lectures, conducted by the science clubs in their own school auditoriums with the help and guidance of men of science. In addition, there will be evening demonstration lectures by well-known scientific men, visits to near-by industrial plants, research laboratories and observatories, and field trips for students of geology and other natural sciences. A special feature is the American Institute's Children's Science Fair, which is held annually at the American Museum of Natural History and consists of science exhibits prepared by school children. Arrangements have also been made for inter-club round table discussions, a Junior Science Clubs Congress and a publication to be sent to all member clubs.

L. W. Hutchins, director of the institute, called attention to the fact that it has been the meeting place of scientific men and laymen for over a hundred years. Now, because of the great interest shown by school

children in the Children's Science Fair (there were over 400 exhibits and 35,000 visitors at last year's fair), it is felt that the institute should broaden its scope. Dr. H. H. Sheldon, president of the institute, expressed satisfaction at the favorable reception the plan had received.

The Junior Science Clubs Plan Committee consists of the following members: Dr. Morris Meister, New York Teacher Training College; Herbert J. Arnold, Lincoln School of Teachers College; Alexander Brodell, Franklin K. Lane High School; Dr. John E. Brolles, George Washington High School; John A. Clark, Alexander Hamilton High School; Alexander Efran, John Adams High School; Irving Fine, James Monroe High School; Charles A. Gramet, John Adams High School; Doris Spier Harman, School Nature League; Rosalie Kant, Bryant High School; William R. Leng, Junior High School No. 55, Bronx; Paul B. Mann, Evander Childs High School; Irving Mosbacher, Morris High School; Professor S. R. Powers, Teachers College; Grace Fisher Ramsay, American Museum of Natural History; B. Taplitz, Grover Cleveland High School; Superintendent John L. Tildsley; Samuel Yacknowitz, Walton High School.

THE LOS ANGELES MEETING OF THE AMERICAN MATHEMATICAL SOCIETY

AT the final session of the recent summer meeting of the American Mathematical Society, held on the Los Angeles campus of the University of California, the following resolution was adopted:

> The American Mathematical Society wishes to place on record its recognition of the Los Angeles meeting as one of the most successful and enjoyable in the history of the society, its admiration for the genius of those who have won and are winning for the mathematical sciences their due place in the amazing cultural development of the Pacific Coast, and its gratitude to all those whose courtesy, hospitality and devoted effort have made the occasion memorable: to Professors E. R. Hedrick and W. M. Whyburn for their unremitting attention to every matter of plan and detail, to all members of the local committee on arrangements and its subcommittees including the faculty, students and ex-students of the University of California at Los Angeles, to Vice-president and Provost Ernest C. Moore, host at the luncheon on Tuesday, to Mrs. Phelps and those associated with her at Mira Hershey Hall, to Professor E. T. Bell and other members of the staff of the California Institute of Technology, to the staff of the Mount Wilson Observatory, to the Los Angeles Chamber of Commerce for assistance in registration, publicity and general information, to Professors D. N. Lehmer and Tibor Rado for their addresses delivered by special invitation of the society, and to Professor J. F. Ritt, whose colloquium, in addition to the significance of its content, has been by unanimous agreement one of the most notable for the lucidity of its oral presentation among all those which the society has heard. The secretary is directed to send copies of this resolution to the persons and groups designated.

SCIENTIFIC NOTES AND NEWS

THE autumn meeting of the National Academy of Sciences will be held at the University of Michigan on November 14, 15 and 16. The regular council meeting will be held on the preceding evening, Sunday, November 13. Members of the local committee are F. G. Novy, *chairman*, H. D. Curtis, C. F. Kettering, Frank Leverett, Walter B. Pillsbury and Moses Gomberg, *secretary*.

HITCHCOCK lecturers at the University of California for the year 1932 to 1933 are: Dr. Peter Debye, professor of physics at the University of Leipzig, September 15 to October 15; J. B. S. Haldane, Sir William Dunn reader in biochemistry at the University of Cambridge, head of the genetical department of the John Innes Horticultural Institute and Fullerian professor of physiology at the Royal Institution, October 15 to November 15, and Dr. George Sarton, research associate of the Carnegie Institution at Washington, lecturer on the history of science at Harvard University, and editor of *Isis*, January 15 to February 15. The establishment of the Hitchcock professorship to bring eminent men to Berkeley for periods of three weeks or longer, is made possible by a bequest, amounting to about $115,000, from the late Mrs. L. Hitchcock Coit. Mrs. Coit asked that this sum be added to a lecture fund presented by her father in 1872, which now amounts to $10,000, and that in honor of her father and mother the chair commemorate their name.

THE Remington Honor Medal for outstanding service to pharmacy has this year been awarded to Eugene G. Eberle, editor of the *Journal* of the American Pharmaceutical Association and a past-president of the organization. The presentation will be made in Baltimore, on October 12, at a testimonial dinner given in his honor by the New York and Baltimore branches of the American Pharmaceutical Association. Among the speakers will be Professor E. Fullerton Cook, chairman of the Revision Committee of the United States Pharmacopoeia; Dr. Henry V. Arny, dean of the School of Pharmacy, Columbia University, and Dr. E. F. Kelly, secretary of the American Pharmaceutical Association.

DR. C. N. MCBRYDE, director of the U. S. Bureau of Animal Industry Experiment Station at Ames, Iowa, was elected an honorary member of the American Veterinary Medical Association at the sixty-ninth annual meeting held at Atlanta, Georgia, from August 23 to 26.

DR. RALPH H. MCKEE, professor of chemical engineering at Columbia University, received the honorary doctorate of natural philosophy from the University of Tartu, Dorpat, Estonia, on the occasion of the tercentenary celebration of its founding.

DR. JULES BORDET, director of the Institut Pasteur of Brussels, was made doctor, *honoris causa,* of the University of Caen, on the occasion of the celebration of the fifth centenary of its foundation by Henry VI of England.

TH. BÄUERLE, director of the Volkshochschule at Württemberg, has been elected honorary senator by the university at Tübingen.

DR. PARKE R. KOLBE, president of the Polytechnic Institute of Brooklyn, has resigned to accept the presidency of the Drexel Institute. His service in Philadelphia begins on October 1.

DR. A. G. POHLMAN, professor of anatomy at St. Louis University, will succeed the late Dr. G. R. Albertson as dean of the school of medicine and professor of anatomy at the University of South Dakota.

J. T. STRATE, assistant professor of mechanical engineering at the University of Arkansas for the last eight years, has been appointed head of the mechanical engineering department at South Dakota State College. He succeeds H. C. Solberg, who died this summer after serving for forty years.

DR. W. B. UNGER has been appointed chairman of the department of zoology at Dartmouth College.

DR. EDWARD W. MORRISON has been appointed assistant professor of bacteriology in the New Jersey College for Women.

LLOYD R. SIMONS, for the past four years county agent leader on the faculty of the New York State College of Agriculture at Cornell University, has been appointed director of extension. He succeeds Dr. Carl E. Ladd, who is now dean of the Colleges of Agriculture and Home Economics.

DR. WALTER LANGDON BROWN has been appointed Regius professor of physic in the University of Cambridge in succession to Sir Humphry Rolleston, who retired on September 30 on the completion of his term of office. Dr. Brown is consulting physician to the Metropolitan Hospital, senior medical officer of the Provident Mutual Life Assurance Company and an examiner in medicine to the University of Cambridge.

E. J. W. BARRINGTON, of Oriel College, Oxford, has been appointed lecturer in zoology at University College, Nottingham.

DR. HAROLD MOORE, who has for many years been director of metallurgical research at the Research Department, Woolwich, England, has been appointed director of the Research Association, to succeed Dr. R. S. Hutton, who has been elected to the new Goldsmith professorship of metallurgy at the University of Cambridge.

THE directors of Imperial Chemical Industries, Limited, England, have released Sir Frederick Keeble, F.R.S., from executive and routine duties as controller of their Agricultural Research Station at Jealott's Hill, in order that he may be more free to devote himself to the many important problems now arising in the application of scientific results to modern agriculture. Sir Frederick Keeble remains a member of the Imperial Chemical Industries Research Council, and will continue to serve the company in an advisory capacity.

DR. CHAS. C. ADAMS, director of the New York State Museum at Albany, has been elected chairman of the Science Section of the American Association of Museums. Dr. Carl E. Guthe, director of the Museum of Anthropology, University of Michigan, is secretary.

DR. C. W. WARBURTON, director of extension of the U. S. Department of Agriculture, has been designated by Secretary Hyde to act as contact officer for the department in connection with its participation in the Century of Progress Exposition, which is to be held in Chicago in 1933, opening on June 1 and closing on November 1. In this capacity Dr. Warburton will arrange, in cooperation with the Office of Exhibits, Extension Service, with all bureaus and offices of the department and with allied industries, all details of the department's participation in the exposition.

DR. ALEXIS CARREL, of the Rockefeller Institute for Medical Research, arrived in New York on September 19 after spending two months in Brittany.

WILLIAM LLOYD WARNER, of the Peabody Museum, Harvard University, has returned from archeological exploration in County Clare, Ireland.

DR. R. S. BASSLER, head curator of geology in the U. S. National Museum, has returned from field-work in the Silurian and Mississippian strata of the central states, where he has been engaged in the study of the stratigraphy and in collecting fossil echinoderms for the Springer Collection. He was success-

ful in obtaining several hundred crinoids and blastoids in addition to specimens of other classes of fossils.

JASON R. SWALLEN, assistant botanist in the Grass Herbarium of the U. S. National Museum, has returned from a several weeks' trip to Yucatan. He visited Chichen Itza, Uxmal, Peto, Lake Chichenkanab, Tulum and Cozumel Island, the last by airplane. He brought back a collection of grasses, sedges and parasitic rusts. The trip was made in cooperation with the University of Michigan and the Carnegie Institution of Washington.

DR. FRANCIS G. BENEDICT, director of the Nutrition Laboratory of the Carnegie Institution of Washington at Boston, left the United States on August 18, accompanied by Mrs. Benedict, for a tour of several months in Europe. They attended the Fourteenth International Physiological Congress in Rome and are now visiting various research institutions and physiological laboratories, conducting investigations on basal metabolism and related subjects. They expect to return to the United States in March, 1933. Dr. Benedict will lecture, by special invitation, at several institutions on the techniques and findings of the Nutrition Laboratory.

DR. WALTER S. MCCLELLAN, medical director of the Saratoga Springs Commission of the State of New York, sailed on September 22 for six months' study and research in Europe. In London he will be in conference with Dr. Fortescue Fox and Dr. W. S. C. Copeman, of the International Society of Medical Hydrology. He plans to go to Paris for the International Congress on Rheumatic Conditions and for a council meeting of the International Society of Medical Hydrology. The following three months he will spend in work with Dr. Franz M. Groedel at the Kerckhoff Institute for Study of Affections of the Heart at Bad Nauheim. The last two months will be spent at the Hydrotherapeutic Station of the Virchow Hospital in Berlin, under Professor Laqueur, the director. He will also spend some time with Professor Zoerkendoerfer at Marienbad.

THE New York State Museum has received a donation of geological specimens, historical objects, Indian materials and copies of old publications of the museum from Mrs. Edward E. Davis, of Norwich. The collections were made by the late Edward E. Davis, and have been given to the museum in accordance with his wish.

THE Field Museum of Natural History has received a new shipment of 4,000 photographic negatives of historic plant specimens preserved in the herbarium of the Botanical Garden and Museum of Berlin. The total number of such photographs being gathered as a joint project of Field Museum and the Rockefeller Foundation of New York has reached a total of 20,000. The shipment came from J. Francis Macbride, assistant curator of taxonomy, who for three years has been in Europe engaged in the work of carrying out this project. The museum has also received a collection of some 1,100 specimens of South American plants, for the herbarium of the department of botany from Dr. F. C. Hoehne, of the Biological Institute of São Paulo, Brazil. According to Paul C. Standley, associate curator of the herbarium, this gives the museum a representation of Brazilian plants of the coffee family which is not equalled in any other herbarium of the United States.

AN exhibition of material relating to the metric system, to celebrate its formal introduction into Austria sixty years ago, was opened in the Museum für Kunst und Industrie, in Vienna, on September 15. It will remain open until October 30.

PROFESSOR W. D. BANCROFT, of Cornell University, the founder and editor of *The Journal of Physical Chemistry,* announces that arrangements have been completed whereby, beginning on January 1, 1933, Williams and Wilkins, of Baltimore, Maryland, will publish the journal. It is in its thirty-sixth volume. Until eleven years ago all deficits were met by Professor Bancroft, but since this time they have been covered by the Chemical Foundation, Inc. The foundation not being able to continue this support after 1932, the new arrangements have been made. For the last eleven years editorial responsibility has been shared by the Chemical Society (London), the Faraday Society and the American Chemical Society. The members of the editorial board representing the British societies are at present W. E. Garner, James Kendall, T. M. Lowry and J. R. Partington. Those representing the American Chemical Society are J. N. Pearce, J. H. Walton, H. B. Weiser and F. K. Cameron. The terms of Drs. Weiser and Cameron expire with the calendar year, and J. W. McBain and T. R. Briggs have been elected to succeed them. Professor Bancroft will retire as editor and his successor, to take office on January 1, 1933, is about to be elected by the editorial board.

PUBLIC lectures at the New York Botanical Garden are being given through the season from September 3 to November 26 on Saturday afternoons at 3:30 o'clock. The speakers with their subjects during October and November are as follows: October 1, "Dahlias," Dr. Marshall A. Howe, assistant director; October 8, "Jungles and Gardens in Florida," Dr. H. Beaman Douglass, physician; October 15, "Autumn Coloration," Dr. A. B. Stout, director of the laboratories; October 22, "Grasses, the Plants of Greatest

Economic Importance to Man," Dr. Elmer D. Merrill, director-in-chief; October 29, "Our Native Ferns," Mr. Albert C. Smith, associate curator; November 5, "Australia, Past and Present," Dr. Arthur Hollick, research associate in paleobotany and Dr. Forman T. McLean, supervisor of public education; November 12, "Crocuses and How to Use Them," Mrs. Wheeler H. Peckham, honorary curator of Iris and Narcissus collections; November 19, "Planting the Bulbs," Mr. Kenneth R. Boynton, head gardener; November 26, "A Winter in Bermuda," Dr. Fred J. Seaver, curator.

APPORTIONMENT of $5,000,000 emergency forest highway funds to be expended in thirty-four states and territories in the fiscal year 1933 has been approved by Secretary Hyde. Building of new highways in the national forests will be begun at once to give employment and open up the national forests to greater use and protect them from fire. The $5,000,000 is part of the 322,000,000 voted by Congress for public works as an emergency measure. Vermont and Mississippi share in national forest highway apportionment this year for the first time.

MORE than 100,000,000 trees were distributed by State forestry departments for forest planting in 1931, says the Forest Service on the basis of reports from the States. These were grown in State nurseries. The figure does not include any privately grown trees. Of the total number, 25,500,000 were sent out for farm planting, 38 States and 2 Territories cooperating with the Forest Service in this activity. In addition, 52,500,000 were planted on State lands and 24,800,000 were distributed for planting on private lands other than farms. Total plantings of all these three classes were nearly 30 per cent. over 1930. In total trees distributed for planting on all classes of lands other than national forests, New York led, Michigan was second, and Pennsylvania third. In farm plantings Pennsylvania led, followed by New York, Ohio, Puerto Rico, and Michigan. Pines and spruces were far in the lead among the species sent out for farm planting. Under the Clarke-McNary Act the Forest Service cooperates with the States in growing forest trees for planting on farms. Distribution is made through the State forestry agencies direct to farmers and usually at cost. The Federal Government does not distribute any stock for State or private planting.

DISCUSSION

THE FUNDAMENTAL PARTICLES

THE experiments of Millikan and Anderson on the tracks due to cosmic radiation in an expansion chamber offer very convincing evidence for a positive particle whose mass is small compared with the mass of the proton. This extremely important observation indicates that it may be profitable to examine more seriously the suggestions from the theoretical side that there are different possible aspects of the electron. The fact that the theory has resisted so stubbornly the efforts to dispose of the negative energy electron or to distort the positive electron into a proton causes us to regard it now with increased respect.

The present theory of the electron seems to lead inevitably to an electron with negative energy and—with the help of the assumption due to Dirac that the negative energy states are almost all filled—to a positive electron of the same mass. Furthermore, as Dirac has shown, the theory provides for a magnetic pole with its corresponding negative energy states and pole of opposite sign. The existence of any one of these particles seems practically to imply all the others. We may therefore regard any one of them, *e.g.*, the electron, as the fundamenal particle. Or perhaps we could say more conservatively that the electron and the Dirac magnetic pole are the fundamental particles.

The problem then arises of constructing with these constituents alone all the observed physical entities. In other words, we require models of the proton, the neutron and possibly the photon. The last could be constructed of a positive and negative electron so close that the potential energy almost compensates the rest mass. The separation would be of the order of 10^{-13} cm. The system would have higher levels and the low level would not be reached in one transition. The jumps on the way down would result in radiation of half the frequency of the exactly analogous hydrogen frequency. Unfortunately, if these were emitted in the sun, they would not be easily visible, as Lyman $_\alpha$ would occur at 2430 Å and the limit of the Balmer series would be above 7200 Å, so that no lines would appear in the visible region.

There is, however, another possibility, much more interesting to the present writer, which depicts the photon as a combination of an ordinary and a negative energy electron. Under suitable conditions the Dirac equation for such a system reduces to one close to that customarily used for the photon. The mass term vanishes and the system moves with the velocity of light.

The most interesting new feature of the program is the picture of the neutron. This is built of a positive and negative magnetic pole. The argument by which the existence of the Dirac pole is inferred suggests that not only is the ratio of pole strength of the magnetic to the electric particle equal to $\frac{1}{2\alpha}$

(where $\alpha = \frac{2\pi e^2}{hc} \sim \frac{1}{137}$), but their potentials are everywhere in that ratio. This leads to a mass for the magnetic pole of $\frac{m}{4\alpha^2}$ where m is the mass of the electron. If now the Dirac equation for the combination of two poles is examined the normal level turns out to have an energy corresponding to a mass approximately (within a factor 2) equal to that of the proton. Moreover, the energy differences between adjacent levels are of the order of 10^9 volts. This is therefore by far the simplest system so far considered which could explain the emission of cosmic radiation.

The proton is of course a combination of a neutron and a positive electron. These then suffice for the building of nuclei. The process of β emission is obvious, even though there are no electrons in the nucleus.

Unfortunately, the considerations mentioned here suffer because the relativistic two body problem has not yet been solved. It can only be hoped that the reduction to a one body problem, which was resorted to in all the examples given, will prove a working approximation in these cases as it has in other cases, where, however, relativistic effects were less important.

I am indebted to Drs. Millikan and Anderson for their kindness in making me acquainted with their experimental results.

R. M. LANGER
NORMAN BRIDGE LABORATORY OF PHYSICS,
CALIFORNIA INSTITUTE OF TECHNOLOGY,
SEPTEMBER 10, 1932

LIGHT A FACTOR IN RANCIDITY

IN the June 3 (1932) issue of SCIENCE is published a brief résumé of the work carried on by the Food Research Division of the Bureau of Chemistry on the subject indicated. The conclusions confirm in general the results which had been obtained in these laboratories and which were made public at the spring meeting of the American Chemical Society, held at Columbus, Ohio, from April 29 to May 3, 1929. Our study of the catalytic activity of various wave-lengths of light upon the oxidation of fats and oils has shown that light transmitted by blue glass is the least effective in this respect, while that transmitted by amber glass is the most effective.

The results will shortly be published in one of the scientific journals.

GEORGE E. HOLM
GEORGE R. GREENBANK
BUREAU OF DAIRY INDUSTRY,
WASHINGTON, D. C.

AN UNUSUAL COTTON PLANT

ON June 8, 1932, the writer, accompanied by Mr. Philip Beltrán, was studying the Tangüis cotton in the Pisco Valley. On Hacienda "San Jacinto," a most interesting plant was found. The fibers produced by this plant were uniformly 1⅛ inches long, with the exception of from 15 to 20 per each seed which measured 1¾ inches. These extra long fibers had the same general characteristics as the others, but were very prominent because of the extra length. All the cotton of the plant was picked, and each seed has been carefully examined. The long fibers were found on every one. In every instance, these long fibers were attached at about the middle of the seed and the number per seed varied only slightly. The writer has examined hundreds of plants of Tangüis and other varieties of cotton, but never before had seen such a variation in the length of the fiber.

The Tangüis cotton originated from a single plant found by Señor Fermín Tangüis, Hacienda "Urrutia," Pisco. A careful study of this variety has given sufficient evidence to state that the first plant was undoubtedly a field hybrid between one of the native Peruvian cottons and an unknown variety of American Upland cotton grown in Peru under the name of "Suave" or "Egipto."

A. F. KIDDER
ESTACION EXPERIMENTAL DE LA
ASOCIACION DE HACENDADOS DE CAÑETE,
CAÑETE, PERU

A METEOR IN WISCONSIN

AT 8:25 P. M., on August 22, a meteor of great brilliancy and of unusual size passed over central Wisconsin. The light was so brilliant that the landscape was lighted up as by a powerful searchlight and sharp shadows of trees were cast on the street in front of my house. We first saw it in the s-w quadrant at an apparent elevation of approximately forty-five degrees. Before it disappeared it had crossed the east-west line, with which its path made an angle of about twenty degrees. That is, the direction of its flight was west, twenty degrees north.

Its apparent angle of fall was about forty degrees. The real angle of its path with the horizon must have been considerably less or else its height was very much greater than we estimated (one mile). Its apparent size was about that of the full moon, it was dazzlingly white with a greenish blue blaze of color close to its surface.

Both my son, Dr. H. E. Culver, and his wife, as well as myself distinctly saw what appeared to be melted globules rolling back and disappearing in the fiery train which streamed out behind the meteor. Nothing was observed by us to fall toward the earth and we heard no sound as the meteor passed, but some two

minutes—estimated—after its disappearance we heard quite a loud report as of an explosion. Other observers in various parts of the state report hearing a roaring sound and all, without exception, report that an explosion either accompanied (the disappearance) or else followed the disappearance at varying intervals according to different observers.

Reports from several localities spoke of the finding of fragments of the meteorite. All these localities were visited by me and the specimens examined with negative results in all cases.

At Neillsville, Wisconsin, some 60 miles west of Stevens Point, I talked with two intelligent observers separately—who estimated the flight to be further north than I did. One thought the course a little east of north and the other that it was a little west of north. They were both out in the open (golf links) and so had a very fine view of the spectacle. One of them thought the object was as large as a bushel basket; the other said it seemed to him as large as a gasoline barrel. The meteor was seen as far south as Racine and as far north as Green Bay, Wis., a distance of about 150 miles.

G. E. CULVER

STEVENS POINT, WISCONSIN
SEPTEMBER 6

REPORTS

DOCTORATES CONFERRED IN THE SCIENCES BY AMERICAN UNIVERSITIES, 1931–1932

THE Research Information Service of the National Research Council, with the cooperation of the registrars of the various American universities, is again able to present information regarding the doctorates in science.

The following data for the academic year 1931–32 supplement those in SCIENCE 72: 357–358 (1930) and 74: 659–660 (1931), where a survey is given for the period 1898–1930 and 1930–1931.

Detailed data for the year 1931–1932, with the comparative statistics for the past ten years and with the names of the recipients of the degrees and the

TABLE I

DOCTORATES CONFERRED ACCORDING TO SUBJECTS

	'23	'24	'25	'26	'27	'28	'29	'30	'31	'32
Chemistry	185	251	250	257	270	278	310	317	390	420
Zoology	45	42	71	55	70	89	91	102	117	127
Physics	54	58	59	76	92	78	101	91	94	113
Psychology	46	51	51	60	74	66	112	97	105	104
Botany	64	57	69	69	53	61	76	81	81	79
Mathematics	28	32	24	47	46	44	61	75	73	75
Engineering	5	5	2	11	10	28	34	49	25	47
Bacteriology	32	12	20	21	20	29	26	27	38	46
Physiology	20	17	17	43	35	28	37	46	46	46
Geology	34	41	25	27	42	35	45	63	39	45
Pathology	21	12	5	4	16	31	27	31	26	43
Agriculture	10	11	16	19	19	31	27	29	45	31
Anatomy	10	5	4	11	13	11	15	12	11	16
Astronomy	6	7	3	7	9	3	8	4	11	8
Med. and Surg.	..	..	..	..	..	..	..	4	2	8
Public Health	..	..	..	3	4	4	15	8	20	8
Metallurgy	2	2	3	10	4	13	8	4	5	7
Anthropology	3	3	2	5	3	5	13	6	7	6
Geography	7	3	13	11	14	7	12	17	6	5
Archeology	0	0	0	0	0	0	2	2	2	3
Paleontology	2	2	1	7	0	1	2	6	3	2
Seismology	..	..	..	..	..	..	..	..	..	2
Meteorology	0	0	0	0	0	0	2	0	0	0
Mineralogy	1	1	4	4	2	0	1	3	1	0
Totals	575	611	640	748	796	842	1025	1074	1147	1241

TABLE II

DOCTORATES CONFERRED ACCORDING TO UNIVERSITIES

	'23	'24	'25	'26	'27	'28	'29	'30	'31	'32
Chicago	71	75	59	78	86	70	99	94	82	116
Wisconsin	44	41	64	53	55	60	66	86	86	88
Cornell	41	60	39	43	62	67	60	80	57	80
Johns Hopkins	58	44	36	50	44	56	62	58	67	67
Ohio State	21	20	33	25	30	25	48	50	74	61
Columbia	58	57	51	49	62	46	61	44	51	56
Minnesota	17	23	23	30	29	41	53	53	47	58
Yale	34	22	41	38	34	38	47	43	53	57
Michigan	15	25	15	32	30	52	38	55	55	55
California	27	20	31	38	42	37	50	47	48	48
Illinois	33	20	32	44	31	36	34	43	45	46
Harvard	31	35	25	35	42	33	40	40	49	45
Iowa	12	16	19	28	24	32	38	28	33	43
Iowa State	..	9	12	14	13	26	28	26	39	34
Mass. Inst.	11	18	18	13	18	13	20	29	16	32
Pittsburgh	7	5	8	7	11	13	8	15	15	31
Pennsylvania	8	12	12	14	27	18	24	26	19	27
Princeton	9	17	15	12	18	17	25	22	16	27
Calif. Inst.	0	9	8	15	8	18	22	18	23	21
Stanford	8	14	15	17	17	17	26	26	28	21
Indiana	5	5	8	7	5	8	9	11	7	16
Brown	3	3	8	4	4	5	7	9	7	14
New York	10	2	5	7	4	11	13	10	23	13
Washington	0	1	3	1	1	5	8	5	6	13
Cincinnati	3	4	7	8	5	1	14	6	13	12
Penn. State	..	..	..	..	1	4	3	3	8	11
Northwestern	2	6	2	4	6	8	5	8	13	10
Rutgers	..	..	..	2	3	9	4	5	5	10
Texas	1	0	0	1	3	0	7	6	5	10
Nebraska	2	5	7	2	2	3	4	6	7	9
Wash. U. St. L.	8	2	0	5	7	2	7	7	8	8
West. Reserve	..	..	..	..	..	..	3	5	9	8
Catholic	1	3	3	6	5	8	6	2	7	7
Duke	..	..	..	..	..	..	4	4	5	7
Kansas	2	2	4	8	8	5	10	11	5	7
Radcliffe	3	2	3	3	2	1	2	5	2	7
Colorado	1	0	1	3	1	3	3	2	3	5
G. Washington	13	5	6	4	4	2	5	2	3	5
Mich. State	0	0	1	4	2	2	6	2	8	5
Missouri	0	5	4	3	7	2	3	6	9	5
Rochester	..	..	1	0	3	3	0	2	5	5
St. Louis	..	..	..	..	2	3	2	3	4	5
Virginia	1	3	5	5	8	3	5	12	9	5
American	..	..	..	3	3	3	1	5	3	3
Bryn Mawr	0	1	1	2	4	0	1	2	1	3
N. Carolina	2	1	0	7	3	4	3	6	12	3
Syracuse	0	0	0	2	3	2	1	5	1	3

TABLE II—*Continued*

DOCTORATES CONFERRED ACCORDING TO UNIVERSITIES

	'23	'24	'25	'26	'27	'28	'29	'30	'31	'32
Clark	8	3	6	7	7	5	11	11	4	2
Maryland	0	1	5	6	3	6	8	3	12	2
Purdue	..	..	..	..	..	..	1	4	6	2
Rensselaer	0	2	0	2	2	7	3	2	4	2
Rice	0	1	2	1	1	3	4	3	5	2
Vanderbilt	..	..	..	..	..	..	..	..	3	2
Fordham	2	0	2	2	1	2	8	6	4	1
George Peabody	..	..	..	..	..	..	..	..	3	1
Oregon	..	..	..	1	0	0	0	2	1	1
Tulane	..	..	..	..	1	2	1	1	0	1

TABLE II—*Concluded*

DOCTORATES CONFERRED ACCORDING TO UNIVERSITIES

	'23	'24	'25	'26	'27	'28	'29	'30	'31	'32
S. Col. Wash.	..	..	..	..	..	..	..	1	3	1
Arizona	..	..	..	..	1	0	0	0	1	0
Boston	1	0	0	1	0	0	0	2	0	0
Georgetown	..	..	..	..	..	..	1	0	2	0
Marquette	..	..	..	..	..	1	0	0	1	0
Mass. State	1	1	0	1	0	1	1	3	4	0
Notre Dame	1	2	0	0	0	0	1	3	2	0
N. Y. S. Col. For.	..	..	..	1	1	2	2	0	1	0
Totals	575	611	640	748	796	842	1025	1074	1147	1241

TABLE III

DISTRIBUTION OF DOCTORATES FOR THE CURRENT YEAR BY UNIVERSITY BY SUBJECT

	Agriculture	Anatomy	Anthropology	Archeology	Astronomy	Bacteriology	Botany	Chemistry	Engineering	Geography	Geology	Mathematics	Medicine and Surg.	Metallurgy	Paleontology	Pathology	Physics	Physiology	Psychology	Public Health	Seismology	Zoology	Total
American								1									1					1	3
Brown						2		5				3										4	14
Bryn Mawr											1							1	1				3
California		1	2	1	1	1	6	11		1	1	1				1	8	4	1		1	7	48
Calif. Inst. Tech.								6	6		2	1					6						21
Catholic								1	1			2					2		1				7
Chicago		2			2	5	16	32		2	4	13	1			3	9	8	8			11	116
Cincinnati								10				1					1						12
Clark										1									1				2
Colorado								3			1											1	5
Columbia			2			1	4	29	1		3	1					2		10			5	58
Cornell	4	1				4	3	17	2		1	9			1	9	4	4	4			17	80
Duke								4											2			1	7
Fordham								1															1
George Peabody																			1				1
George Washington								1			1					1			1			1	5
Harvard				1	1		3	18			3	6					8		4			1	45
Illinois	3						2	23	1		2	3					5		2			5	46
Indiana							1	4			2	1					6		1			1	16
Iowa								19			3	4			1		3		10			3	43
Iowa State	5					7	1	15	3					1								2	34
Johns Hopkins				1		2		25	4		2	2	1			2	3	5	6	5		9	67
Kansas								4									1		2				7
Maryland	1						1																2
Mass. Inst. Tech.						1		14	11			1		1			4						32
Michigan					2	1	4	8	11		1	6					9	1	2	2		8	55
Michigan State	1					1	2	1															5
Minnesota		2				2	3	19	1		3		6			6	5	4	6			1	58
Missouri	1						1	1			2												5
Nebraska							1	4											2			2	9
New York		1						6			2	1				1	2						13
North Carolina								2			1												3
Northwestern		1						4			1					1		2	1				10
Ohio State	1					1	5	18	3	1		4					4	3	9			12	61
Oregon																	1						1
Pennsylvania						1	2	8				2					2	1	8			3	27
Penn. State	2						2	7															11
Pittsburgh						1	3	15				2					3		1			6	31
Princeton					1			11			4	3					2	3	2			1	27
Purdue							1	1															2
Radcliffe					1							3					1	1				1	7
Rensselaer									1					1									2
Rice																	2						2
Rochester						1		2										2					5
Rutgers	3					1	1	2								1		1				1	10

TABLE III—*Concluded*

	Agriculture	Anatomy	Anthropology	Archeology	Astronomy	Bacteriology	Botany	Chemistry	Engineering	Geography	Geology	Mathematics	Medicine and Surg.	Metallurgy	Paleontology	Pathology	Physics	Physiology	Psychology	Public Health	Seismology	Zoology	Total
St. Louis	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	2	.....	.....	1	.....	5
Stanford	.....	.....	.....	.....	.....	.....	1	7	1	.....	1	1	.....	.....	.....	1	1	1	6	.....	.....	1	21
State College Wash.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	1
Syracuse	.....	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	3
Texas	.....	.....	.....	.....	.....	.....	3	1	.....	.....	.....	2	.....	.....	.....	.....	2	.....	1	.....	.....	1	10
Tulane	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Vanderbilt	.....	1	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2
Virginia	.....	.....	.....	.....	.....	.....	1	2	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1	5
Washington	.....	.....	.....	.....	.....	1	2	7	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	13
Wash. Univ. St. Louis	.....	1	.....	.....	.....	.....	3	2	.....	.....	.....	.....	.....	.....	.....	1	1	.....	.....	.....	.....	.....	8
Western Reserve	.....	1	.....	.....	.....	.....	.....	4	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	1	.....	.....	1	8
Wisconsin	6	1	.....	.....	.....	8	4	29	.....	.....	2	2	.....	2	.....	13	6	3	5	.....	.....	7	88
Yale	4	2	2	.....	.....	4	1	16	1	.....	2	.....	.....	2	.....	1	7	.....	4	1	.....	10	57
Totals	31	16	6	3	8	46	79	420	47	5	45	75	8	7	2	43	113	46	104	8	2	127	1241

titles of the theses, will be found in Reprint and Circular Series No. 104. Earlier numbers of this series, containing such data for earlier years, are 26, 42, 75, 80, 86, 91, 95, 101. Copies of these may be obtained from the Publication Office, National Research Council, Washington, D. C.

CLARENCE J. WEST
CALLIE HULL

SCIENTIFIC APPARATUS AND LABORATORY METHODS

RELATION OF ANATOMY AND METHOD OF EXTRACTION TO QUALITY OF SATSUMA ORANGE JUICE[1]

RECENT research carried out jointly by the Division of Horticultural Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture and the Florida Agricultural Experiment Station, has yielded some preliminary results of immediate value to those interested in the subject of the quality of expressed citrus juices, as affected principally by the physiological anatomy, type, variety and maturity of citrus fruits.

A definite correlation was first established, while working with ripe Kawano Wase Satsuma oranges, between certain methods of preparation and the development of a bitter taste in the prepared juice on aging.

In Method No. 1 the juice was pressed from juice sacs only between porcelain plates. Result: Pleasantly tart taste, no bitter taste developed after 24 hours at room temperature; retained good quality in refrigerator for several days; deep chrome color, no change.

In Method No. 2 the juice was pressed from the halved unpeeled fruits between an inverted cup and a form fitting over it. Result: Pleasantly tart taste with added flavor of citrus oil, no bitter taste developed after 24 hours; color changed from deep chrome to light yellow within an hour.

In Method No. 3 the juice was pressed from the whole peeled fruit by means of a conical worm in a fluted housing. Result: Developed bitter taste in 2 hours and became exceedingly bitter after 4 hours; deep chrome color, no change.

In Method No. 4 the pulp was reamed out by means of a revolving cone. Result: Developed bitter taste in 2 hours and became exceedingly bitter after 4 hours; deep chrome color, no change.

Supplementing the technique indicated, specific methods were employed to separate the fruit into eight complex tissue fractions: (1) Outer peel; (2) inner peel and veins; (3) locular walls; (4) central axis; (5) seed coat; (6) cotyledons and germ; (7) empty juice sacs and (8) juice pressed from juice sacs only. The process was in some cases carried one step further—oil was pressed from outer peel, glucosides and pectins were extracted from the inner peel and veins, etc. The possible effect of the various com-

[1] Cooperative research between Bureau of Plant Industry, U. S. Department of Agriculture, and Florida Agricultural Experiment Station.

plex tissue fractions when present in the prepared citrus juice mixture was determined by testing out the effect of infusions of the tissues when mixed with juice pressed from juice sacs only. The causal agent responsible for the bitter taste was identified as of glucosidal origin with a regional distribution mainly in the inner peel and veins and locular walls. The degree of development of the bitter taste in prepared citrus juices on aging is apparently dependent upon fruit maturity, citrus type and variety, method of extraction and possibly after-treatment.

The causal agent for the indicated color changes was traced to the outer peel, and identified as citrus oil.

The practical application of these preliminary results is readily apparent. With an understanding of the causes responsible, measures may be taken in the preparation of the juice to reduce the bitter taste to a minimum and to mask slight traces of the bitter taste by bringing in a trace of citrus peel oil. Color changes, from the deep orange of Satsuma and tangerine to lighter shades of orange or to yellow, and the change from orange or deep yellow of sweet orange to lighter shades of orange or to yellow may be controlled. The relative stability of the mixture as a whole is also a subject which concerns the producer, since stratification within the juice mixture may not only affect the color but also the taste qualities. The complete data will be published shortly. In connection with the subject, it should be stated that other problems are under investigation, including attempts to determine the cause of undesirable taste qualities other than bitterness. These results will be reported later.

HAMILTON P. TRAUB
LEONARD W. GADDUM
A. F. CAMP
A. L. STAHL

A KNOCKDOWN "BERLESE FUNNEL"

As several persons have shown interest in a collapsible desiccation trap which I have used with considerable satisfaction for about fifteen years, I am publishing its specifications so that any one may have one made up for his own use.

The Italian acarologist used the cumbersome hot-water jacket as a heating or drying unit. A convenient laboratory substitute is the incandescent bulb. For field and travel I have used the sunshine and altered the frame so as to pack flat. In brief, the trap consists of a framework of zinc or brass strips one inch wide, cut from material one sixteenth of an inch thick. The strips are soldered together so as to make up five T-shaped pieces (uprights), and one asterisk shaped plate, as shown in Fig. 1. The T-pieces (uprights) have the cross-piece seven inches long and the leg ten inches long bent where it joins the cross-piece, as shown. The three notches are slightly wider than the thickness of the material. The asterisk plate (which functions as a leg stabilizer) has

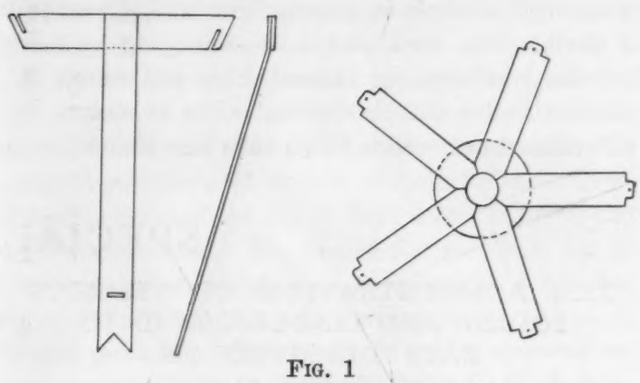

FIG. 1

a central hole (seven eighths inches in diameter for receiving vials to three quarters inches in diameter) cut into the central disc (three inches in diameter). The total length of the arms (measuring from center of the asterisk) is four and five eighths inches. The terminal tongues are a half inch broad, and designed to fit into the slot at the base of the legs. The holes in these tongues should be one sixteenth inch from base of the tongues and of the diameter of a common straight pin.

To assemble this frame, dovetail the notches of the ends of the heads of the five uprights—thus forming a pentagon. Insert the tongues of the stabilizing plate into the slots at the base of the legs, and drop pins into the holes.

The funnel is cut from a piece of stiff paper or pamphlet cover (cardboard) and pinned together along the overlapping edges. I keep two or three such funnel sheets on hand. For the above dimensions a radius of ten and a quarter inches is satisfactory, with a three-quarter inch semicircle cut out of the apex (center of base of funnel sheet). I always use a smaller funnel below the major to take up the space between the vial and the funnel in case there is a gap, as there often is.

The sieve, which is dropped into the mouth of the funnel, fits into the funnel about an inch below the rim, if eight inches in diameter. It may be made of copper mosquito netting soldered to a ring made of three-sixteenth inch wire.

Such a trap may be set up in half a minute. The moss, leaf mould or vegetable débris is spread on the sieve (a pound tin full) and the trap placed on the ledge of a hotel window, steamer deck, balcony, city roof or in the backyard to sun. If the vegetable layer is two inches deep (loose) on the sieve it is best to let it sun through the day.

To kill the catch, drop into the vial, after it has

stood quietly a minute or two, a teaspoonful of boiling water, heated over a flame of alcohol held in the lid of a small tin-can, like that of a small-sized George Washington coffee tin.

A useful adjunct in regions where sunshine is rare or not dependable is an electric light bulb, fifteen feet of flexible wire cord, and a two-way plug to screw into the hotel lighting fixture. This will enable the collector to dry out his material while he sleeps.

Needless to say much débris falls into the vial with the arthropods. It is better to sort out the specimens while they are still alive by sprinkling the contents of the vial on a white card and searching it under a small portable dissecting binocular microscope, but if this can not be done at the time, the sorting can be done years later—preserving the specimens with the débris, after the boiling water has cooled, in seventy per cent. alcohol.

ARTHUR PAUL JACOT

MONROE, CONNECTICUT

SPECIAL ARTICLES

THE ADMINISTRATION OF FERROUS IODIDE AND LINOLEIC ACID TO RATS DEPRIVED OF VITAMIN A[1]

MINUTE doses of ferrous iodide were administered daily by Chidester, Eaton and Thompson[2] to rats depleted of vitamin A, and in some cases of vitamin D as well, with the result that for a period of 14 weeks the animals gained in weight at almost the same rate as the positive controls, and were apparently cured of xerophthalmia, although a standard vitamin A-free diet was fed. Chidester, Eaton and Speicher[3] reported approximately the same findings in slightly greater detail. Chidester[4] and Chidester and Wesson[5] discussed the importance of the combinations of dietary substances with respect to iodine, iron and particularly to the unsaturated fatty acids which had just been shown by Burr and Burr[6] to be essential to life. The belief that benefits might accrue to rats deficient in vitamin A from the administration of iodine and of iron, together with essential fatty acids, was put to the test by Chidester, Eaton and Speicher,[7] who fed ferrous iodide and linoleic acid to rats deficient in vitamin A. Resumption of growth and cure of xerophthalmia were reported and interpreted to indicate mobilization of the vitamin stores in the body as well as an actual substitution for vitamin A by the ferrous iodide and linoleic acid.

Neither Mason[8] nor Cameron[9] has been able to confirm the results that Chidester and his associates secured by feeding ferrous iodide to animals depleted of vitamin A. We have likewise been unable to detect any beneficial effects as a result of the administration of ferrous iodide, linoleic acid or of ferrous iodide in combination with linoleic acid.

ANIMAL EXPERIMENTS

Male rats, weighing 38 to 50 gm at 21 days of age, were given *ad libitum* Sherman's diet No. 380. This consists of extracted casein 70 per cent., starch 20 per cent., yeast 5 per cent., salt mixture[10] 4 per cent., and sodium chloride 1 per cent.; in addition, a daily supplement of 0.001 mg of irradiated ergosterol dissolved in oil was administered. When the animals had ceased to grow and had developed severe xerophthalmia (ca. 40 days) they were divided into five groups which received, respectively, daily supplements of 0.1 cc distilled water, 1 drop of cod-liver oil + 0.1 cc distilled water, 0.1 cc ferrous iodide solution (0.1 cc contained 0.024 mg of ferrous iodide), 0.1 cc of linoleic acid, and 0.1 cc of ferrous iodide solution + 0.1 cc of linoleic acid. The supplements, with the exception of the cod-liver oil, were delivered into the mouth by syringe. The water was given to the positive and negative controls to insure the same amount of handling for all the animals. The ferrous iodide solution was made up daily just before use.

All rats were examined at death for infections of the middle ears, of the glands at the base of the tongue and of the salivary glands, as well as for renal and bladder calculi.

RESULTS

The results in Table 1 indicate the complete ineffectiveness of any of the supplements, except cod-liver oil, either for the promotion of growth or the cure of xerophthalmia. At autopsy one or more of the typical

[1] The expenses of this investigation were shared by the Connecticut Agricultural Experiment Station and the Carnegie Institution of Washington, D. C.

[2] F. E. Chidester A. G. Eaton and G. P. Thompson, SCIENCE, 68, 432. 1928.

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[4] F. E. Chidester, *Collecting Net*, 5, 36. 1930.

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[8] K. E. Mason, *Anat. Rec.*, 51, Supplement 1, Abstract 91. 1931.

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lesions, associated with vitamin A deficiency, was found in all the rats that did not receive cod-liver oil.

TABLE 1

Rat	Supplement	Duration of depletion	Duration of supplementation	Body weight: Maximum before supplementation	Body weight: Final	Body weight: Change
		days	*days*	*gm*	*gm*	*gm*
C4454	0.1 cc ferrous iodide solution	35	24	108	74	−34
C4478	"	38	29	150	87	−63
C4500	"	38	19	148	113	−35
C4508	"	39	25	143	92	−51
C4612	"	46	16	149	102	−47
Average		39	23	140	94	−46
C4451	0.1 cc linoleic acid	35	40	111	84	−27
C4477	"	38	17	135	90	−45
C4499	"	39	13	119	78	−41
C4506	"	38	11	142	126	−16
C4611	"	31	15	128	87	−41
Average		36	19	127	93	−34
C4450	0.1 cc ferrous iodide solution + 0.1 cc linoleic acid	34	44	113	80	−33
C4476	"	60	8	154	95	−59
C4496	"	38	7	119	106	−13
C4504	"	37	25	80	58	−22
C4610	"	43	10	140	84	−56
Average		42	19	121	85	−36
C4452	0.1 cc water	34	17	106	95	−11
C4502	"	38	12	131	105	−26
C4510	"	45	20	142	82	−60
C4614	"	37	14	102	73	−29
C4615	"	33	46	107	72	−35
Average		37	22	118	85	−33
C4457	0.1 cc water + 1 drop cod-liver oil	39	28 (eyes cured 7 days)	119	200	+81
C4495	"	36	28 (eyes cured 6 days)	100	198	+98
C4613	"	36	28 (eyes cured 6 days)	115	197	+82
Average		37		111	198	+87

The condition of the eyes of the rats that received ferrous iodide alone appeared, upon superficial examination, to be improved, inasmuch as the bloodiness disappeared and the eyes were open. Several rats given supplements of distilled water alone likewise showed this apparent improvement shortly before death. The condition was designated by Dr. A. M. Yudkin, associate clinical professor of ophthalmology at Yale University, as an advanced stage of the xerophthalmia in which the eyes are dry and exhibit Bitot's plaques under the lids. It is possible that Chidester may have mistaken this condition for a cure of the xerophthalmia.

A careful survey of the data presented by Chidester and coworkers led us to the belief that their experimental conditions were not in accordance with the accepted standards of modern vitamin testing. Their animals were depleted for 80 days before supplements were administered. We regard the necessity for so long a period of depletion as an indication either that the diet was not adequately purified from vitamin A, or that the animals had been allowed to store an excessive quantity of this vitamin prior to the experimental period. In either case, at the time supplementation of the diet was begun their animals were 110 days old. Our rats showed marked evidence of depletion of vitamin A in approximately 40 days, and none survived for 80 days unless given cod-liver oil. The control rats in Chidester's experiments were badly stunted, inasmuch as their average weight was only 135 gm at 161 days of age; this was 63 gm less than our control rats that were only 86 days old, and 1 gm less than his best group of experimental rats deprived of vitamin A. That animals, supposedly deprived of vitamin A, should survive for 161 days (131 days on experiment) suggests that an undiscovered source of vitamin A was available. Perhaps some of the confusion has arisen from the fact that a number of the animals employed in Chidester's experiments were depleted of both vitamins A and D, later being given a source of vitamin D. In any event some or all of the possible objectionable factors mentioned—vitamin A in the diet in small amounts, large stores of vitamin A in the rats at the beginning of the experiment, and simultaneous depletion of the animals of vitamins A and D—seem to have resulted in a stunted non-reactive animal which could not be expected to give the clear-cut responses required in vitamin work.

Conclusions

The administration of ferrous iodide and linoleic acid, alone and in combination, was ineffective as a cure for xerophthalmia, as a stimulant to growth, or as a preventive of infection or renal disturbance in rats deprived of vitamin A.

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EFFECT OF AGE AND SEX ON RESISTANCE OF DAPHNIDS TO MERCURIC CHLORIDE

IN connection with an experiment involving the killing rate of daphnids by mercuric chloride[1] it seemed desirable to test the resistance of the different ages and sexes of these animals to the poison.

The animals were *Daphnia magna*, grown in the laboratory at Iowa City in the culture medium of Banta.[2] All those used for the age experiment were parthenogenetic females of the same clone; those of the different sexes were in their early adult instars.

Two methods of noting the killing time were used. In one series, the animals were observed individually under the microscope and the killing time (time of the last observable body movement) noted with a stop-watch. In the other series, the animals were placed in the poison solution in groups of 20 to 30, and at the end of a specified time the action of the poison stopped or slowed down, either by the action of a neutralizing chemical like potassium ferrocyanide, which had been previously tested and found to be non-toxic in the concentration used, or by the addition of enough water to throw the whole mixture into a dilution far below the lethal concentration for the time interval involved. The number dead and alive were roughly determined and the animals returned to the normal culture medium as soon as possible. They were then allowed to stand for a time sufficient to separate definitely into two groups, dead and alive. Doubtful cases were examined microscopically before being classified.

A dilute solution (0.0003N) was used for the group method of killing in order to have the total elapsed time fairly long. For the individual observations a more concentrated solution (0.01N) gave killing times more convenient for stop-watch notation.

In the accompanying tables the killing time is the time taken to kill 50 per cent. of the animals. This is determined by plotting the data in the form of a sigmoid curve (per cent. dead against elapsed time) and taking for the killing time the point of intersection of this killing curve with the line drawn through 50 per cent. dead. All times are given in seconds.

TABLE I

INDIVIDUAL OBSERVATION, 0.01N $HgCl_2$, 26° C.

Instar	Killing time
1	77
2	86
3	98
4	111
5	113
6	134
7	136

TABLE II

GROUP METHOD OF KILLING, INSTARS 4 AND 5 TREATED TOGETHER, 0.0003N $HgCl_2$, 25° C.

Instar	Killing time
1	380
2	402
3	444
4 & 5	460
6	520

TABLE III

GROUP METHOD, 0.0003N, 26° C.

Males	400
Parth. females	442
Sexual females	462

(In the series summarized in Table II, instars 4 and 5 were treated together because of the close similarity between these two ages shown in the preceding series. Instar 7 was omitted because of the loss of the culture by accident before the completion of the experiments.)

The data indicate that there is a decrease in the susceptibility of *Daphnia magna* to the poison as the animals grow older and that the males are more susceptible than the females, with the parthenogenetic forms intermediate between the sexual forms. These differences are no doubt associated with the metabolic differences of the different ages and sexes, as indicated by MacArthur and Baillie[3] and others.

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